Model Radar Implementation Using Ultrasonic Sensor

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ABSTRACT

A Radar is an object detection system which uses electromagnetic waves specifically radio waves — to determine the range, altitude, direction, or speed of both moving and fixed objects .The radar dish, or antenna, transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter. The project is used to identify the target in which direction it is coming and position of object.

Radar signal containing selected target simulations modulates an optical, infrared signal, in accordance with the selected target simulations. Radar target system is provided with selectively direct the modulated IR radiation onto selected areas of an RF (Radar Frequency) array. Radar target identifier is selected with areas of the RF array function to add target angular simulations and target space position and scintillations to the other simulations contained in the radar signal.

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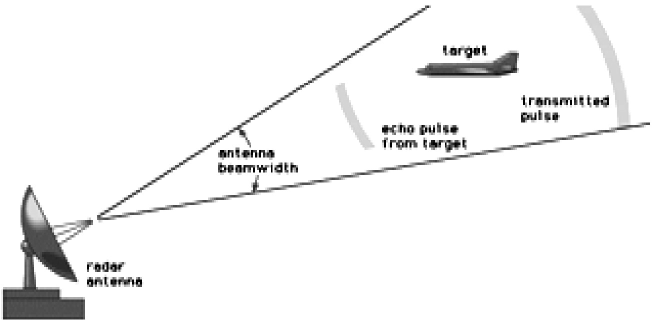
I. INTRODUCTION

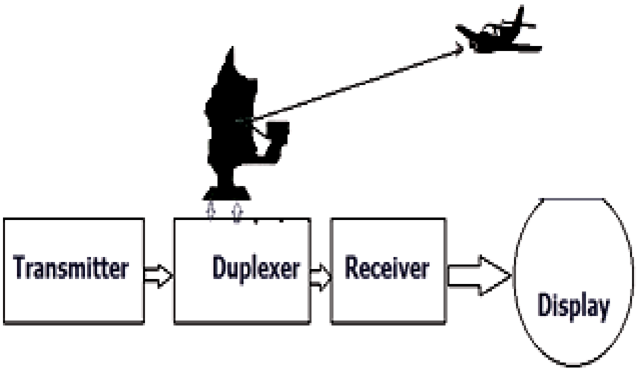
An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result. As everyone in this competitive world prefers to make the things easy and simple to handle, this project sets an example to some extent.

Radar is an object detection system which uses electromagnetic waves specifically radio waves to determine the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. The radar dish, or antenna, transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter.



A radar system has a transmitter that emits radio waves called radar signals in predetermined directions. When these come into contact with an object they are usually reflected and/or scattered in many directions. Radar signals are reflected especially well by materials of considerable electrical conductivity—especially by most metals, by seawater, by wet land, and by wetlands. Some of these make the use of radar altimeters possible. The radar signals that are reflected back towards the transmitter are the desirable ones that make radar work. If the object is moving either closer or farther away, there is a slight change in the frequency of the radio waves, due to the Doppler effect.

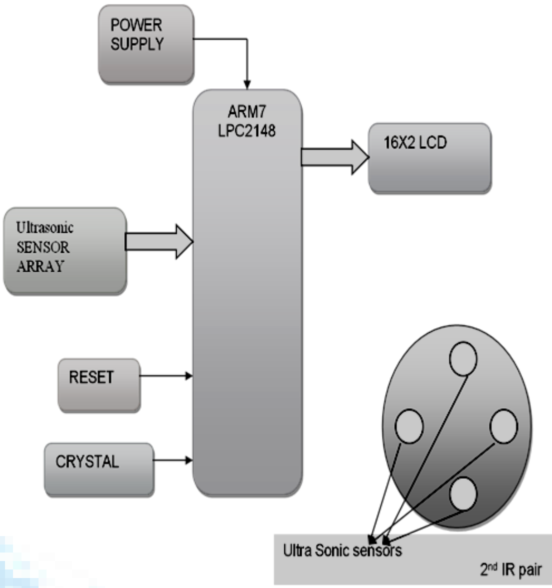
Radar receivers are usually, but not always, in the same location as the transmitter. Although the reflected radar signals captured by the receiving antenna are usually very weak, these signals can be strengthened by the electronic amplifiers that all radar sets contain. More sophisticated methods of signal processing are also nearly always used in order to recover useful radar signals.



The weak absorption of radio waves by the medium through which it passes is what enables radar sets to detect objects at relatively-long ranges—ranges at which other electromagnetic wavelengths, such as visible light, infrared light, and ultraviolet light, are too strongly attenuated. In particular, there are weather conditions under which radar works well regardless of the weather. Such things as fog, clouds, rain, falling snow, and sleet that block visible light are usually transparent to radio waves. Certain, specific radio frequencies that are absorbed or scattered by water vapor, raindrops, or atmospheric gases (especially oxygen) are avoided in designing radars except when detection of these is intended.

Finally, radar relies on its own transmissions, rather than light from the Sun or the Moon, or from electromagnetic waves emitted by the objects themselves, such as infrared wavelengths (heat). This process of directing artificial radio waves towards objects is called illumination, regardless of the fact that radio waves are completely invisible to the human eye or cameras.

Our Model of Paper:



Radar equation:

The power P_r returning to the receiving antenna is given by the radar equation:Pr = $(P_t G_t A_r \alpha F^4) / (4\pi)2 R_t^2 R_r^2)$

where

-
- P_t = transmitter power
- G_t = gain of the transmitting antenna
- A_r = effective aperture (area) of the receiving antenna
- σ = radar cross section, or scattering coefficient, of the target
- F = pattern propagation factor
- R_t = distance from the transmitter to the target
- R_r = distance from the target to the receiver.

In the common case where the transmitter and the receiver are at the same location, $R_t = R_r$ and the term $R_t^2 R_r^2$ can be replaced by R^4, where R is the range. This yields:

$$P_r = \frac{P_t G_t A_r \sigma F^4}{(4\pi)^2 R^4}.$$

This shows that the received power declines as the fourth power of the range, which means that the reflected power from distant targets is very, very small.

The equation above with $F = 1$ is a simplification for vacuum without interference. The propagation factor accounts for the effects of multipath and shadowing and depends on the details of the environment. In a real-world situation, path loss effects should also be considered.

A. Introduction to Embedded System

An Embedded System is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function. A good example is the microwave oven. Almost every household has one, and tens of millions of them are used

every day, but very few people realize that a processor and software are involved in the preparation of their lunch or dinner.

This is in direct contrast to the personal computer in the family room. It too is comprised of computer hardware and software and mechanical components (disk drives, for example). However, a personal computer is not designed to perform a specific function rather; it is able to do many different things. Many people use the term general-purpose computer to make this distinction clear. As shipped, a general-purpose computer is a blank slate; the manufacturer does not know what the customer will do wish it. One customer may use it for a network file server another may use it exclusively for playing games, and a third may use it to write the next great American novel.

Frequently, an embedded system is a component within some larger system. For example, modern cars and trucks contain many embedded systems. One embedded system controls the anti-lock brakes, other monitors and controls the vehicle's emissions, and a third displays information on the dashboard. In some cases, these embedded systems are connected by some sort of a communication network, but that is certainly not a requirement.

At the possible risk of confusing you, it is important to point out that a general-purpose computer is itself made up of numerous embedded systems. For example, my computer consists of a keyboard, mouse, video card, modem, hard drive, floppy drive, and sound card-each of which is an embedded system. Each of these devices contains a processor and software and is designed to perform a specific function. For example, the modem is designed to send and receive digital data over analog telephone line. That's it and all of the other devices can be summarized in a single sentence as well.

If an embedded system is designed well, the existence of the processor and software could be completely unnoticed by the user of the device. Such is the case for a microwave oven, VCR, or alarm clock. In some cases, it would even be possible to build an equivalent device that does not contain the processor and software. This could be done by replacing the combination with a custom integrated circuit that performs the same functions in hardware. However, a lot of flexibility is lost when a design is hard-cooled in this way. It is mush easier, and cheaper, to change a few lines of software than to redesign a piece of custom hardware.

B. History and Future

Given the definition of embedded systems earlier is this chapter; the first such systems could not possibly have appeared before 1971. That was the year Intel introduced the world's first microprocessor. This chip, the 4004, was designed for use in a line of business calculators produced by the Japanese Company Busicom. In 1969, Busicom asked Intel to design a set of custom integrated circuits-one for each of their new calculator models. The 4004 was Intel's response rather than design custom hardware for each calculator, Intel proposed a general-purpose circuit that could be used throughout the entire line of calculators. Intel's idea was that the software would give each calculator its unique set of features.

The microcontroller was an overnight success, and its use increased steadily over the next decade. Early embedded applications included unmanned space probes, computerized traffic lights, and aircraft flight control systems. In the 1980s, embedded systems quietly rode the waves of the microcomputer age and brought microprocessors into every part of our kitchens (bread machines, food processors, and microwave ovens), living rooms (televisions, stereos, and remote controls), and workplaces (fax machines, pagers, laser printers, cash registers, and credit card readers).

It seems inevitable hat the number of embedded systems will continue to increase rapidly. Already there are promising new embedded devices that have enormous market potential; light switches and thermostats that can be central computer, intelligent air-bag systems that don't inflate when children or small adults are present, pal-sized electronic organizers and personal digital assistants (PDAs), digital cameras, and dashboard navigation systems. Clearly, individuals who possess the skills and desire to design the next generation of embedded systems will be in demand for quite some time.

C. Overview of Embedded System Architecture

Every embedded system consists of custom-built hardware built around a Central Processing Unit (CPU). This hardware also contains memory chips onto which the software is loaded. The software residing on the memory chip is also called the ‘firmware’.

The operating system runs above the hardware, and the application software runs above the operating system. The same architecture is applicable to any computer including a desktop computer. However, there are significant differences. It is not compulsory to have an operating system in every embedded system. For small appliances such as remote control units, air conditioners, toys etc., there is no need *for* an operating system and you can write only the software specific to that application. For applications involving complex processing, it is advisable to have an operating system. In such a case, you need to integrate the application software with the operating system and then transfer the entire software on to the memory chip. Once the software is transferred to the memory chip, the software will continue to run *for* a long time you don’t need to reload new software.

Now, let us see the details of the various building blocks of the hardware of an embedded system. As shown in Fig. the building blocks are;

· Central Processing Unit (CPU)
· Memory (Read-only Memory and Random Access Memory)
· Input Devices
· Output devices
· Communication interfaces
· Application-specific circuitry

II. ARM Processor

A. Introduction to ARM

Founded in November 1990, it is spun out of Acorn Computers, it Designs the ARM range of RISC processor cores. Licenses ARM core designs to semiconductor partners who fabricate and sell to their customers. ARM does not fabricate silicon itself, it also develop technologies to assist with the design-in of the ARM architecture. Software tools, boards, debug hardware, application software, bus architectures, peripherals etc.

The ARM processor core originates within a British computer company called Acorn. In the mid-1980s they were looking for replacement for the 6502 processor used in their BBC computer range, which were widely used in UK schools. None of the 16-bit architectures becoming available at that time met their requirements, so they designed their own 32-bit processor.

Other companies became interested in this processor, including Apple who was looking for a processor for their PDA project (which became the Newton). After much discussion this led to Acorn's processor design team splitting off from Acorn at the end of 1990 to become Advanced RISC Machines Ltd, now just ARM Ltd. Thus ARM Ltd now designs the ARM family of RISC processor cores, together with a range of other supporting technologies.

One important point about ARM is that it does not fabricate silicon itself, but instead just produces the design - we are an Intellectual Property (or IP) company. Instead silicon is produced by companies who license the ARM processor design.

B. Architectural overview

The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7TDMI-S processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue. The key idea behind Thumb is that of a super-reduced instruction set. Essentially, the ARM7TDMI-S processor has two instruction sets:

• The standard 32-bit ARM set.
• A 16-bit Thumb set.

C. Ultrasonic Sensor

Humans can normally hear sound frequencies between 20 and 20,000 Hz (20 kHz). When a sound wave's frequency lies above 20 kHz, it is called an ultrasonic wave. While we cannot hear ultrasonic waves, we apply them in various technologies such as sonar systems, sonograms, surgical tools, and cleaning systems. Some animals also use ultrasonic waves in a specialized technique called echolocation that allows them to pinpoint objects and other animals, even in the dark.

The project uses 5 standard transistors to receive and transmit the ultrasound and a comparator to set the threshold echo detection level - so there are no special components other than the microcontroller.The ultrasonic transducers are standard 40 kHz types.Note that the internal oscillator of the MC micro is used and this saves two pins - that can be used for normal I/O,

Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water. To measure the amount of liquid in a tank, the sensor measures the distance to the surface of the fluid. Further applications include: humidifiers, sonar, medical ultrasonography, burglar alarms and non-destructive testing.

Systems typically use a transducer which generates sound waves in the ultrasonic range, above 18,000 hertz, by turning

electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed.

The technology is limited by the shapes of surfaces and the density or consistency of the material. For example foam on the surface of a fluid in a tank could distort a reading.

Ultra sonic Range Finding:

A common use of ultrasound is in range finding; this use is also called SONAR, (sound navigation and ranging). This works similarly to RADAR (radio detection and ranging): An ultrasonic pulse is generated in a particular direction. If there is an object in the path of this pulse, part or all of the pulse will be reflected back to the transmitter as an echo and can be detected through the receiver path. By measuring the difference in time between the pulse being transmitted and the echo being received, it is possible to determine how far away the object is.

The measured travel time of SONAR pulses in water is strongly dependent on the temperature and the salinity of the water. Ultrasonic ranging is also applied for measurement in air and for short distances. Such method is capable for easily and rapidly measuring the layout of rooms.

Although range finding underwater is performed at both sub-audible and audible frequencies for great distances (1 to several kilometers), ultrasonic range finding is used when distances are shorter and the accuracy of the distance measurement is desired to be finer. Ultrasonic measurements may be limited through barrier layers with large salinity, temperature or vortex differentials. Ranging in water varies from about hundreds to thousands of meters, but can be performed with centimeters to meters accuracy.

THEORY

The Ping sensor detects objects by emitting a short ultrasonic burst and then "listening" for the echo.Under control of a host microcontroller (trigger pulse), the sensor emits a short 40 kHz (ultrasonic) burst.

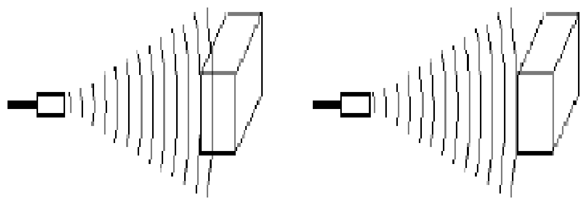
This burst travels through the air at about 1130 feet per second, hits an object and then bounces back to the sensor. The PING sensor provides an output pulse to the host that will terminate when the echo isdetected; hence the width of this pulse corresponds to the distance to the target.

Two Ultrasonic Sensor Types

The following diagrams summarize the distinctions between proximity and ranging ultrasonic sensors:

Proximity Detection:

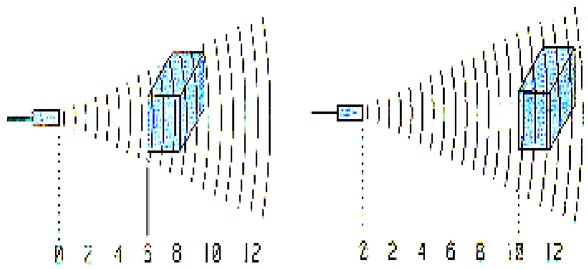
An object passing anywhere within the preset range will be detected and generate an output signal. The detect point is independent of target size, material, or degree of reflectivity.



Objected detected - YES Objected detected - NO

Ranging Measurement:

Precise distance(s) of an object moving to and from the sensor are measured via time intervals between transmitted and reflected bursts of ultrasonic sound. The example shows a target detected at six inches from sensor and moving to 10 inches. The distance change is continuously calculated and outputted.



Calculation for target finding:

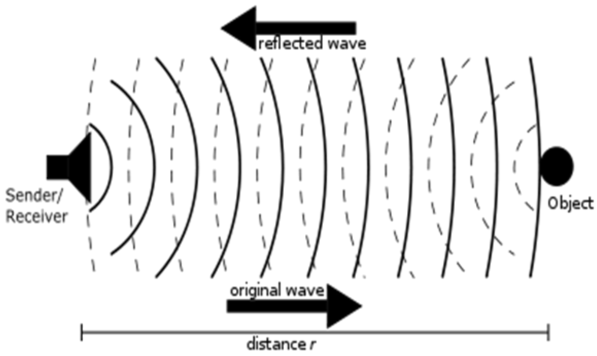
The time from transmission of the pulse to reception of the echo is the time taken for the signal energy to travel through the air to the object and back again. Since the speed of signal is constant through air measuring the echo reflection time lets you calculate the distance to the object using the DST equation:

Distance = (s * t)/2 (in meters)

You need to divide by 2 as the distance is the round trip distance i.e. from transmitter to object and back again.

You can get ultrasonic transducers optimized for 25 kHz, 32 kHz, 40 kHz or wide bandwidth transducers. This project uses a 40 kHz transducer but it will still work with the others if you make simple changes to the software (where it generates the 40kz signal). The receiver and generator circuits will work as they are.If you use a different transducer you must change the software to generate the correct frequency for the transducer as they only work at their specific operating frequency. The 40kz signal is easily generated by the microcontroller but detection requires a sensitive amplifier. I have used a three transistor amplifier for the receiver.

This is followed by a peak detector and comparator which set the sensitivity threshold so that false reflections (weaker signals) are ignored.



Picture of ULTRASONIC SENSOR

If you store the value of timer 1 and then the counter value is starts counting u to the Rx echo completion or as soon as an ultrasonic echo is received.Counter value gives the time delay in machine cycles. Since the project uses a 4MHz main clock then the time delay will be measured in micro-seconds.

The minimum distance of this scheme is about 5cm. looking at the output of the first receiver amplifier shows that it should be more accurate at lower distances - it is inaccurate by about 2cm which is still quite good. Probably the addition of amplifiers for the longer range stops accurate short range operation.The maximum distance is limited by the sensitivity, gain and noise performance of the receive amplifier and also the transmit power and duration of transmission.For this circuit the maximum distance is about 3m.

LIQUID CRYSTAL DISPLAY:

LCD stands for **L**iquid **C**rystal **D**isplay. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
4. Ease of programming for characters and graphics.

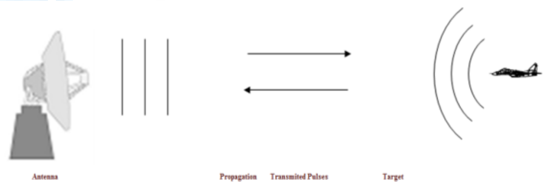
These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (*Hitachi*) and can display messages in two lines with 16 characters each . It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

WORKING PROCEDURE

1. Switch on the power supply.
2. As soon as the power supply is on RADAR gets activated.
3. Then the ultrasonic sensors on the antenna will produce ultrasonic waves to sence the object.
4. Then the area is continuously monitered by RADAR.
5. If any target found in the area it will make buzzer sound to activate base station.
6. RADAR will display the target direction and distance on LCD screen.

Radar Working:



ADVANTAGES & APPLICATIONS

Advantages:

1) Very flexible - can be used in a number of ways
- Stationary mode
- Moving mode
- Two Directional mode

2) Beam spread can incorporate many targets
3) Can often select fastest target, or best reflection
4) Still very reliable
5) High Penetration capability.
6) No need of medium.
7) Long Range

APPLICATIONS:

- Mapping radar scans a large regions for remote sensing and geography applications
- Wearable radar which is used to help the visually impaired
- Air traffic control uses radar to reflect echoes off of aircraft

• Weather radar uses radar to reflect echoes off of clouds
• Weather radars use radio waves with horizontal, dual (horizontal and vertical), or circular polarization
• Some weather radars use the Doppler effect to measure wind speeds
• Missile Tracking System
• Marine radars are used to measure the bearing and distance of ships to prevent collision with other ships

Police forces use radar guns to monitor vehicle speeds on the roads.

III. Conclusion and Suggestions

Radar target system is provided with ultrasonic waves. Radar target identifier is selected with areas to find target angular simulations and target space position and scintillations to the other simulations contained in the radar signal. This project presents Radar modal target Direction identifier with remote station alert system is been designed and implemented with ARM7 in embedded system domain. Experimental work has been carried out carefully.

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